Daily PM2.5 Background Data Technical Support Document

INTRODUCTION

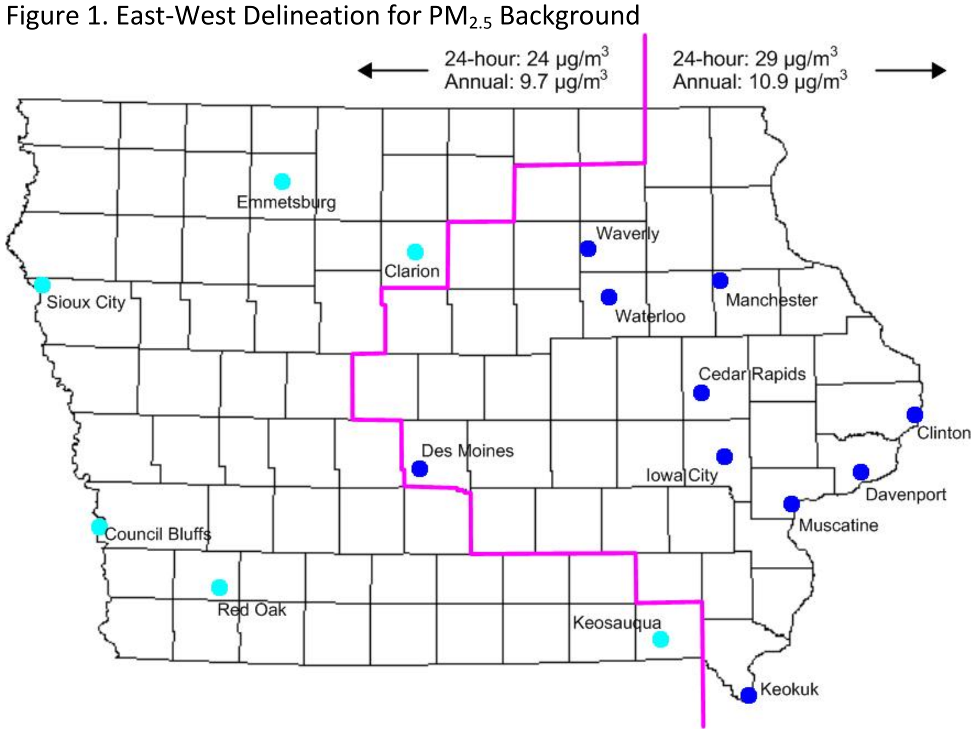
Existing $PM_{2.5}$ concentrations across the state approach the new $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) leaving less air quality resource available for expansion and new construction. It also makes it difficult to show modeled attainment of the NAAQS when new emissions are added to the existing background levels. For this reason the DNR is supplementing the default $PM_{2.5}$ background concentrations with daily background data that can be paired with the model predictions. This practice – known as paired-sums – accounts for the day-to-day variability of the background concentrations.

DEFAULT BACKGROUND VALUES

Normal modeling practice is to add the appropriate maximum model predictions to some single representative background value. The Department has calculated default background values for the state. There are separate values for the east and west portions of the state; these values are based on the average monitoring design values for the monitors located in each portion (Figure 1). Please refer to the Department's "*Use of CAMx in Establishing Statewide Default $PM_{2.5}$ Background Concentrations*" document for further details about the development of these values and the delineation of the East and West portions of the state.

The high default background values will make it difficult in some instances to show modeled attainment of the PM2.5 NAAQS so the Department has determined daily background values that can be used in the analysis. The daily background values were determined using the same East-West delineation described above.

Figure 1. East-West Delineation for $PM_{2.5}$ Background



DAILY BACKGROUND VALUES

The daily background data will be paired with model predictions by date so it is necessary for the background files to cover the same time period as the meteorological data used in the model. The current meteorological data covers the period from 2005 – 2009.

Some $PM_{2.5}$ monitors are intended to measure $PM_{2.5}$ every day, but there is a large portion of them that are only intended to measure $PM_{2.5}$ every third day. These are referred to as 1-in-3 monitors. All such monitors in a region are generally scheduled to make measurements on the same days so comparisons can be made across the monitoring network. Unfortunately, this presents a problem for the development of daily background values because not all days are represented at 1-in-3 sites. Each monitor used in this analysis, along with the period operated and the operating schedule (either daily or 1-in-3) is listed in Table 1.

Table 1. Monitoring Data Used in Analysis.

Monitoring Site Name	Approximate Period / Frequency of Operation *	Location	Portion of the State
Army Reserve	2005 (daily), 2006-2009 (1-in-3)	Cedar Rapids	East
Public Health	2008-2009 (daily)	Cedar Rapids	East
Rainbow Park	2005-2006 (1-in3), 2007-2009 (daily)	Clinton	East
Adams School	Entire Period (1-in-3)	Davenport	East
Jefferson School	Entire Period (daily)	Davenport	East
Cornell School	2005 (1-in-3)	Des Moines	East
Indian Hills Elementary (Clive)	Entire Period (1-in-3)	Des Moines	East
Public Health	Entire Period (daily)	Des Moines	East
Hoover Elementary	2005-2006 (1-in-3), 2007-2009 (daily)	Iowa City	East
Keokuk Fire Station	2007-2009 (1-in-3)	Keokuk	East
Backbone State Park	2008 (1-in-3)	Manchester	East
Franklin School	2009 (1-in-3)	Muscatine	East
Garfield Elementary	2005-2006 (1-in-3), 2007-2009 (daily)	Muscatine	East
Greenwood Cemetery	2009 (1-in-3)	Muscatine	East
Grout Museum	Entire Period (1-in-3)	Waterloo	East
Water Tower	2009 (1-in-3)	Waterloo	East
Waverly Airport	2006-2007 (1-in-3)	Waverly	East
Jannsen Farm	Entire Period (1-in-3)	Clarion	West
Franklin Elementary	Entire Period (1-in-3)	Council Bluffs	West
Iowa Lakes Community College	Entire Period (1-in-3)	Emmetsburg	West
Lake Sugema	Entire Period (1-in-3)	Keosauqua	West
Bryant School	2009 (1-in-3)	Sioux City	West
Lowell School	2005-2008 (1-in-3)	Sioux City	West
Viking Lake	Entire Period (1-in-3)	Red Oak	West

* The period of operation and monitoring frequency listed here is an approximation of the operating schedule. Start and end dates are not exact. Periodic outages and schedule adjustments occurred at all sites and were not considered for this summary.

Daily background values for each portion of the state were calculated by averaging the monitor concentrations for each day. In some cases there were multiple monitors located near each other. When this occurred the concentrations from all monitors near that location were averaged to obtain a single 24-hour average value for that location for each day. This was done so that areas of the state with a higher density of monitors would not bias the background concentration. Then daily East and West background values were calculated by averaging the concentrations at all locations in the corresponding portions of the state.

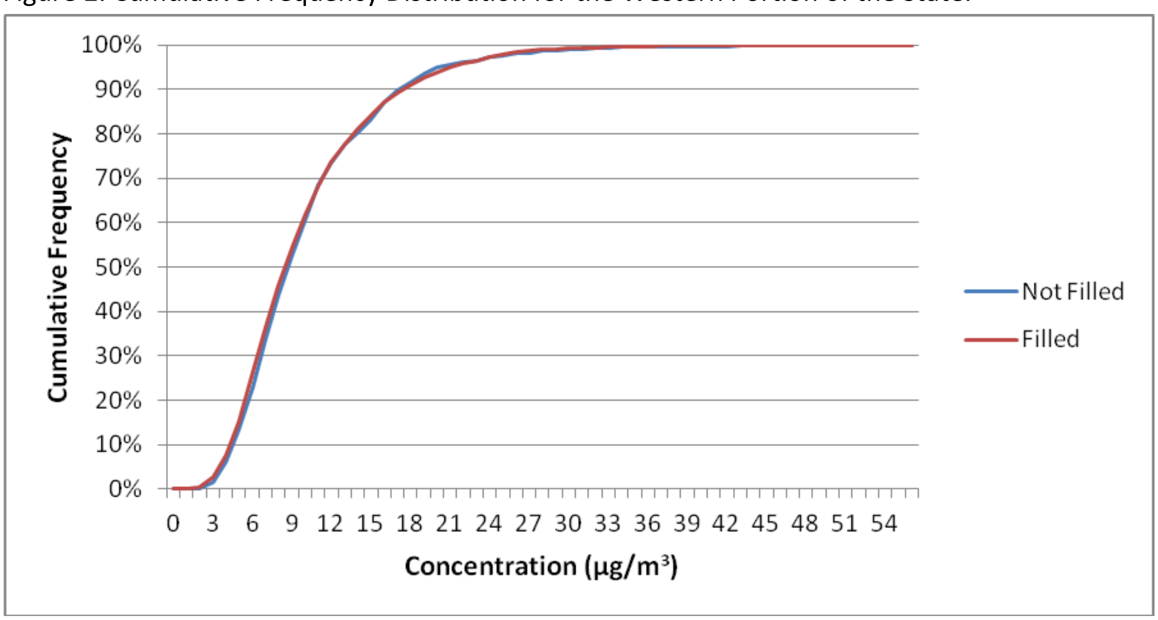
There are several monitors in the eastern portion of the state that operated daily, including two that did so during the entire 2005-2009 period. This, combined with the large number of monitors provided enough data that there was at least one concentration available for every day during the period.

There were fewer monitors in the western portion of the state, and none of them operated on a daily basis. This required that the missing daily background values were filled. The nearby Omaha monitor operated on a daily schedule during the majority of the period (with some outages) and had similar readings to the monitors in western Iowa. Data from Omaha were used to fill in gaps where possible, then the remaining gaps were filled using either the average concentration from the eastern portion of the state, or the default value for the western portion of the state for that day (24 µg/m^3) – whichever was less. The resulting filled data are statistically similar to the unfilled data (Table 2) and the cumulative frequency distributions very closely match (Figure 2).

Table 2. Comparison Statistics

Comparison Statistic	Unfilled Data	Filled Data
Average Concentration	10.07 µg/m^3	9.92 µg/m^3
98th-percentile Concentration	24.39 µg/m^3	24.69 µg/m^3
Standard Deviation	5.68 µg/m^3	5.65 µg/m^3

Figure 2. Cumulative Frequency Distribution for the Western Portion of the State.



MODEL-READY DAILY BACKGROUND DATA

In order to use the resulting hourly background data in AERMOD it is necessary to account for the method the model uses to incorporate these values in the predicted concentration. Specifically, during hours with missing meteorological data or when the wind is calm, the model is incapable of calculating a concentration. During days where there are a large number of hours affected by missing or calm data, calculating a straight average of the remaining hours would bias the model result towards the concentrations predicted during the non-missing and non-calm hours. To account for this potential bias AERMOD modifies the average 24-hour concentration on days where there are more than six hours with missing or calm data by adding the concentrations for all valid hours and then dividing by 18 instead of dividing by the number of valid hours. This affects the background data because this modification is also applied to the hourly background input into the model. Dividing the background by a fewer number of hours than it is intended to represent would result in an under-prediction bias.

Therefore, on the affected days, it is necessary to increase the background concentration input into the model by an amount equal to the decrease that AERMOD will apply. These modifications are site-specific because each meteorological dataset will contain different numbers of missing and calm hours on any particular day. For this reason it was necessary to create separate background input files for use with each meteorological input file as well as for each portion of the state.

Please refer to section 2.5 of the addendum to the *User's Guide for the AMS/EPA Regulatory Model - AERMOD* for additional details and for instructions on how to use the daily background files in AERMOD. Both the user guide and the addendum can be found on EPA's SCRAM website.

The background files contain hourly data even though the background values are daily averages. This is because of the current background file format requirements of AERMOD. The values listed in each background file will be the same for each hour of each day (i.e. if the daily background for a day is 10 $\mu g/m^3$, all 24 hours will have a value of 10 $\mu g/m^3$).

Due to the inherent connection to the meteorological data, the hourly background files will be updated whenever the meteorological input files are updated. It is important that the correct versions of each input file are paired accordingly (Figure 3). The version of each dataset will be indicated by the last letter in the file name, with version "A" being the earliest. In addition, several of the meteorological datasets are divided by the East/West background border. In these cases it is also important to make sure that the correct background dataset is being used. The meteorological datasets that span the division of the background areas are Ames (KAMW), Des Moines (KDSM), Mason City (KMCW), Ottumwa (KOTM) and Waterloo (KALO).

AERMOD does not adjust the annual average concentration in the same way as it does the 24-hour average. Instead it adds the concentrations from all valid hours during the year and then divides by the number of valid hours so these background files should not be used for the annual average. Using the hourly background files as modified for the 24-hour analysis would result in an over-estimation of the annual background concentration. Instead the default annual background value should be added to the total model concentration without using the hourly background input files.

Figure 3. Pairing of Meteorological and PM2.5 Daily Background Data.